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Customer Success Is Our Mission

NextGen Integrated Communications, Navigation, and Surveillance Study

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October 16, 2009

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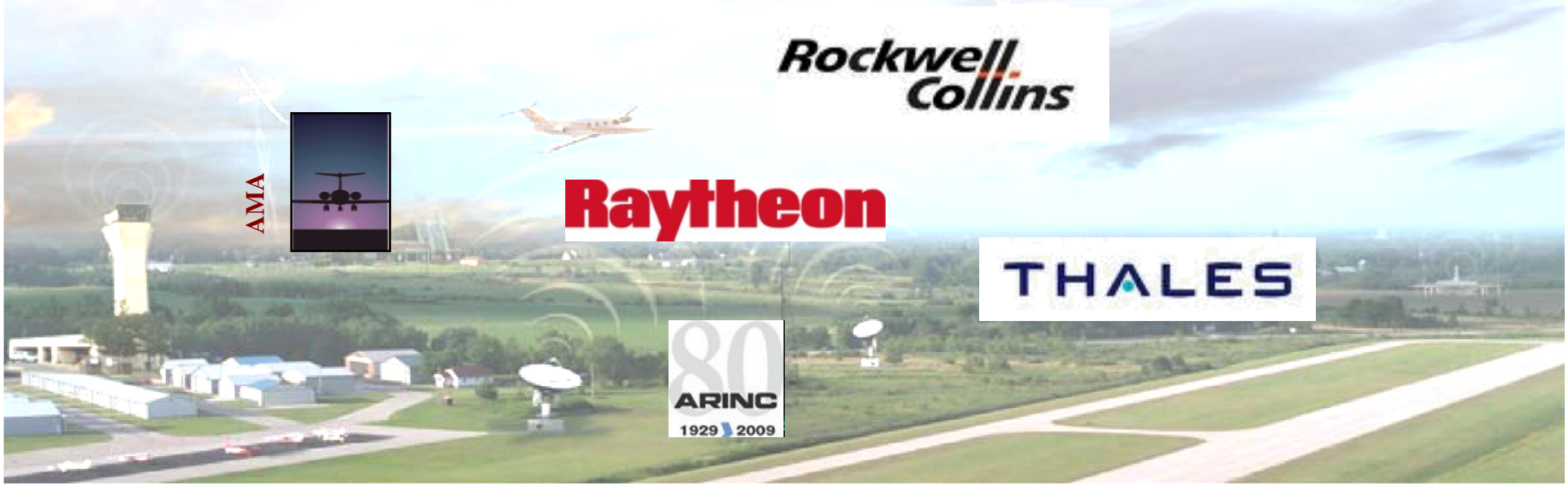
Program Objective

"Having baselined the NextGen Plan... it is necessary to pursue analyses of the key issues facing NextGen stakeholders. ... One of the issue areas is NextGen Integrated Communications, Navigation and Surveillance (ICNS) ... to better understand what would be needed to achieve the far-term ICNS system and the risks associated with pursuing such a system."

NextGen Institute ICNS RFP

Raytheon Team – ICNS expertise and proven process



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What is ICNS???

- Communications

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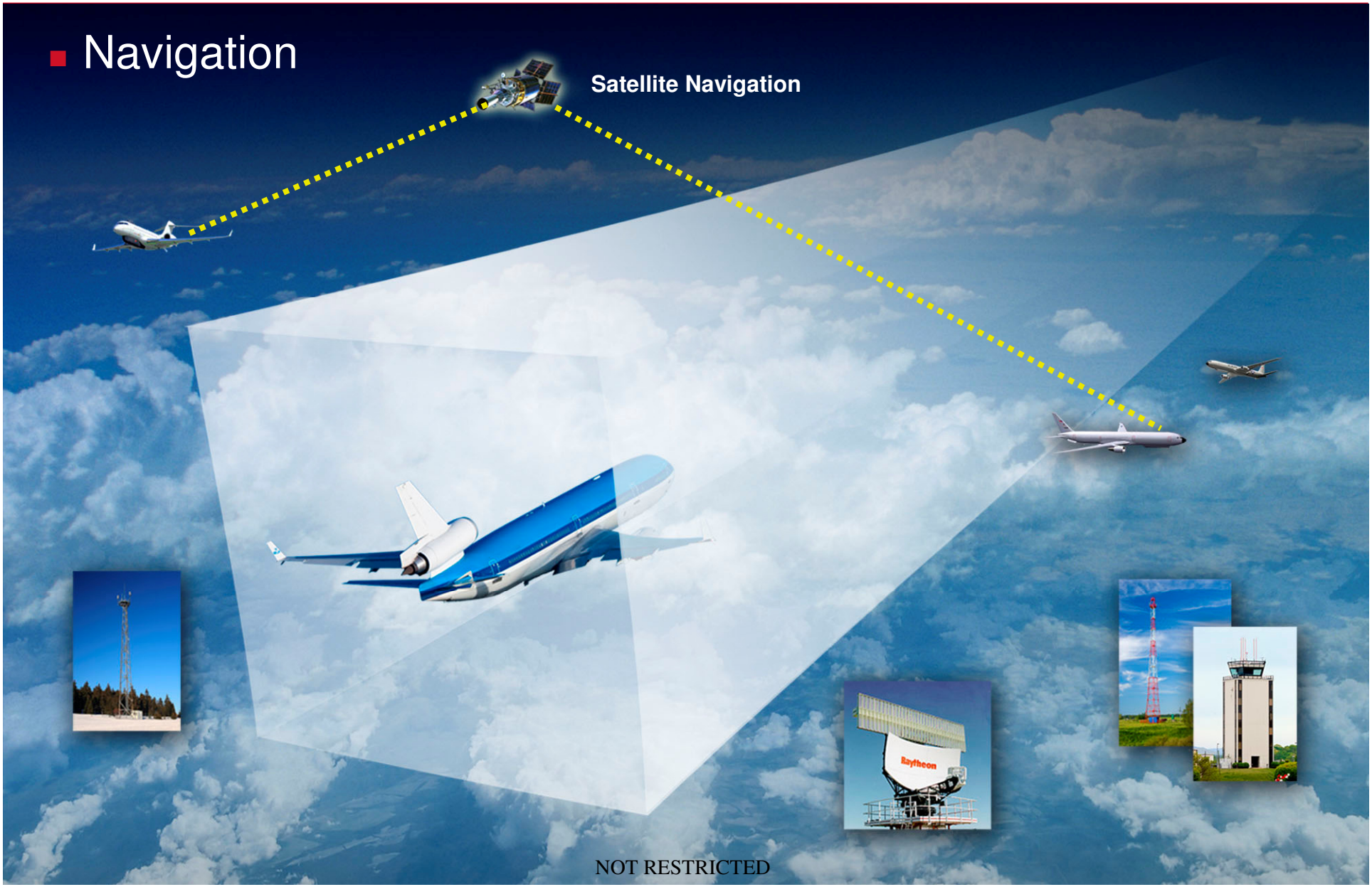
What is ICNS???



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What is ICNS???

- Surveillance

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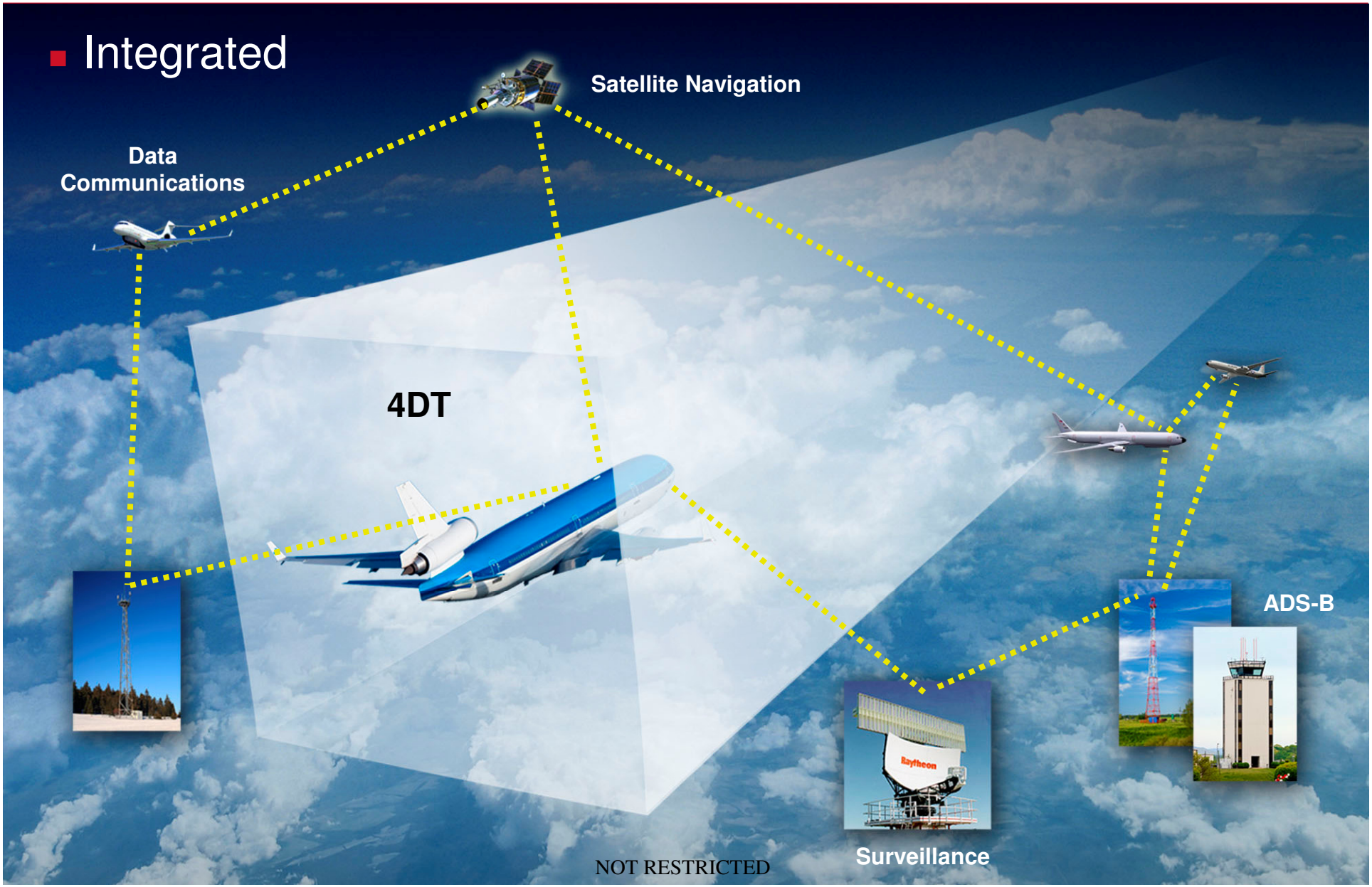
What is ICNS???



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Study Objective

- Are today's plans providing the NextGen ICNS capability envisioned for 2025?
- Are there viable alternative paths to NextGen ICNS?

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Scenario Based Process

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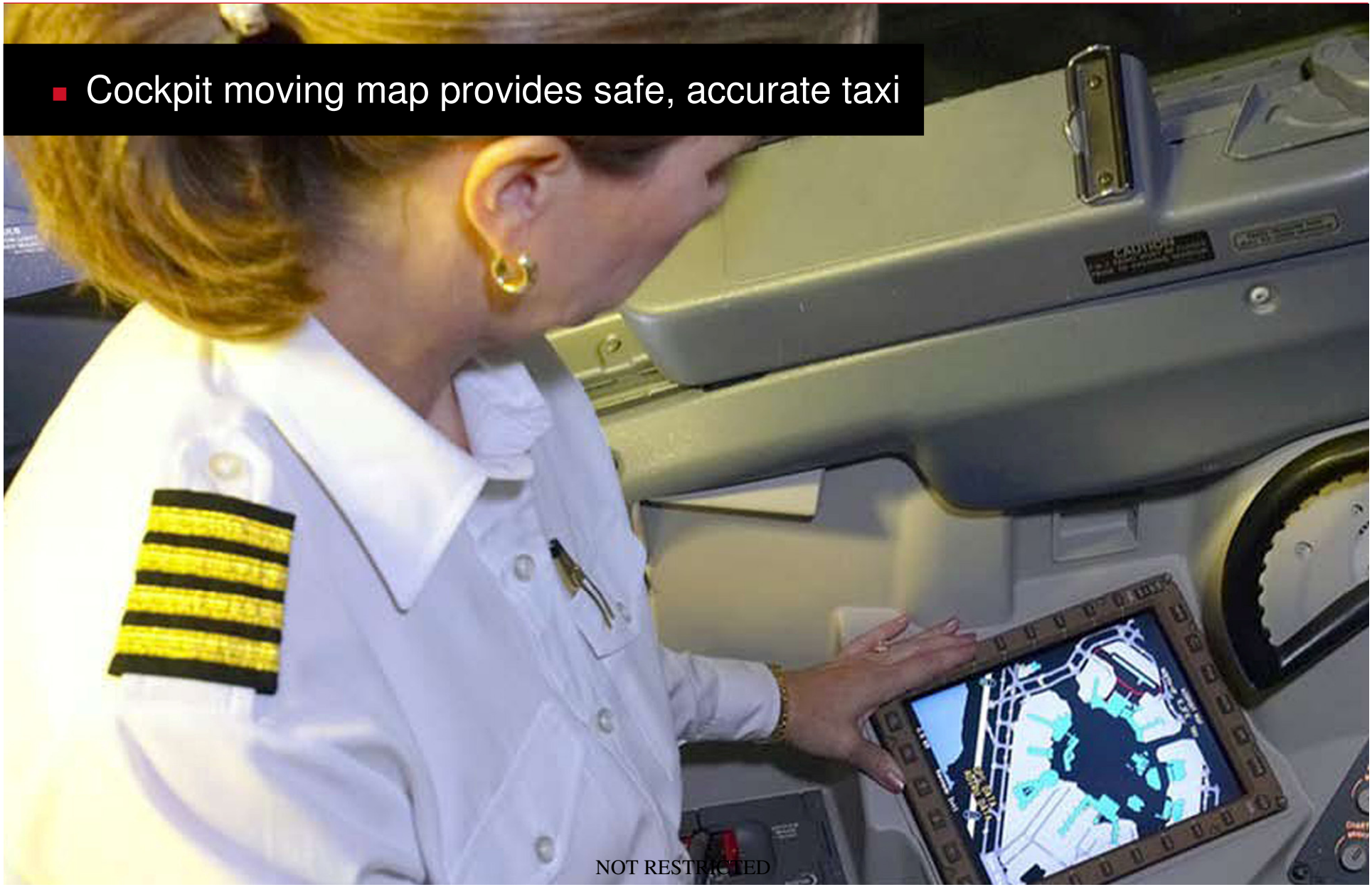
Scenario Based Process



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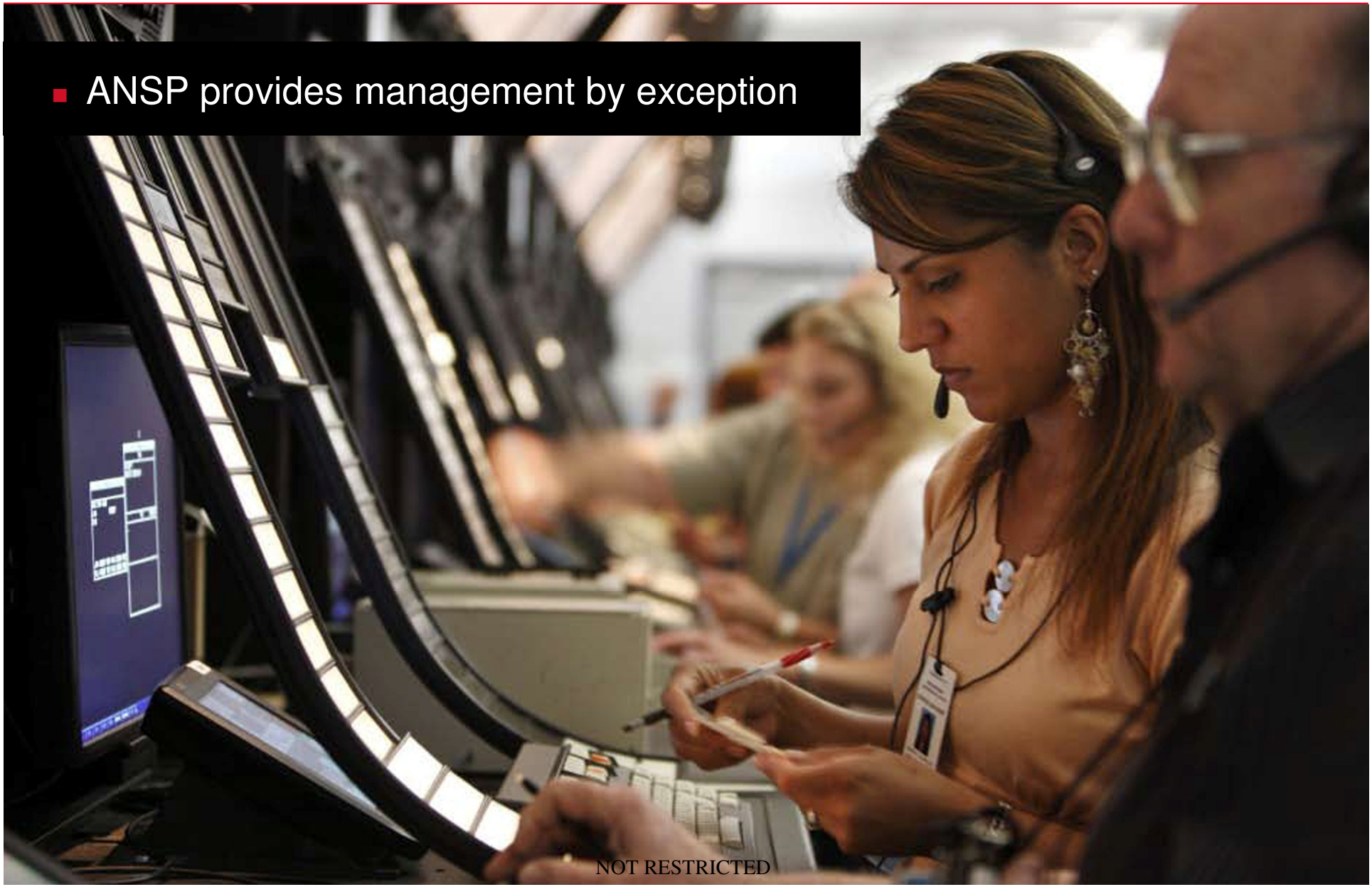
Scenario Based Process



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Scenario Based Process

- Sunset Air takes advantage of RNP departure with optimal climb

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Scenario Based Process

- Agreed 4DT includes cruise climb

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Scenario Based Process

- There's an encounter with UAV and Special Use Airspace

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Scenario Based Process

- ANSP authorizes Sunset Air for self separation over the Gulf of Mexico

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Scenario Based Process

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Scenario Based Process

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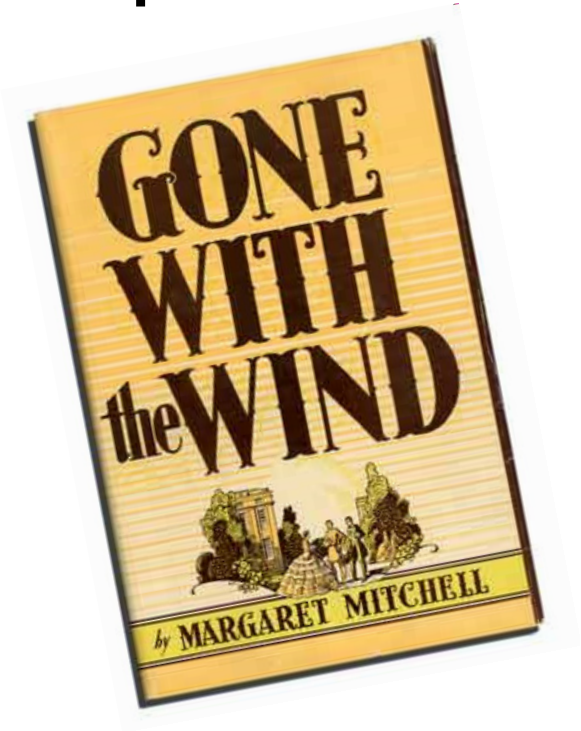
Scenario Based Process

Convert the narrative description of the novel …



… into the detailed breakdown of the script identifying location, actors, stage directions, and dialogue

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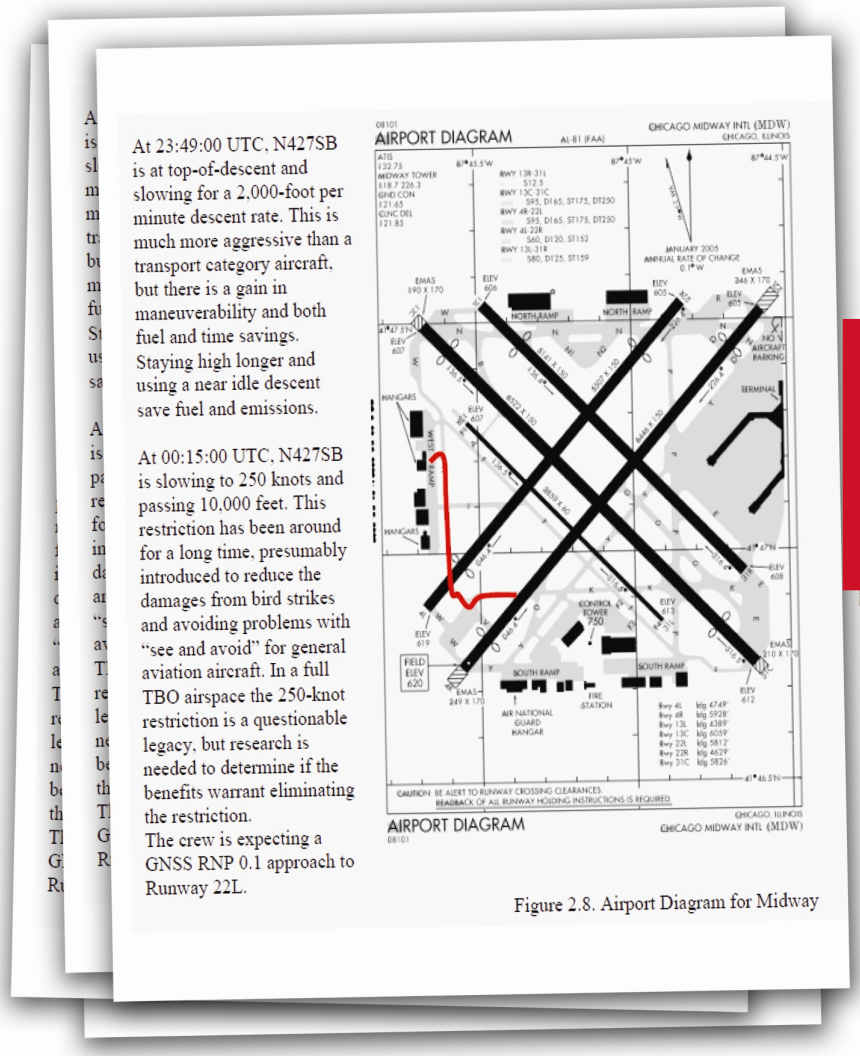
Scenario + Enterprise Architecture



At 23:49:00 UTC, N427SB is at top-of-descent and slowing for a 2,000-foot per minute descent rate. This is much more aggressive than a transport category aircraft, but there is a gain in maneuverability and both fuel and time savings. Staying high longer and using a near idle descent save fuel and emissions.

At 00:15:00 UTC, N427SB is slowing to 250 knots and passing 10,000 feet. This restriction has been around for a long time, presumably introduced to reduce the damages from bird strikes and avoiding problems with "see and avoid" for general aviation aircraft. In a full TBO airspace the 250-knot restriction is a questionable legacy, but research is needed to determine if the benefits warrant eliminating the restriction.
The crew is expecting a GNSS RNP 0.1 approach to Runway 22L.

AIRPORT DIAGRAM — CHICAGO MIDWAY INTL (MDW)

Figure 2.8. Airport Diagram for Midway

Scenario Narratives

Create Use Case

1. **Translate scenarios into time sequenced action steps**
2. **ID "who" initiates action and "where"**
3. **Describe the action**
4. **ID "who" receives the results and "where"**

Validate with Subject Matter Expert Walkthroughs

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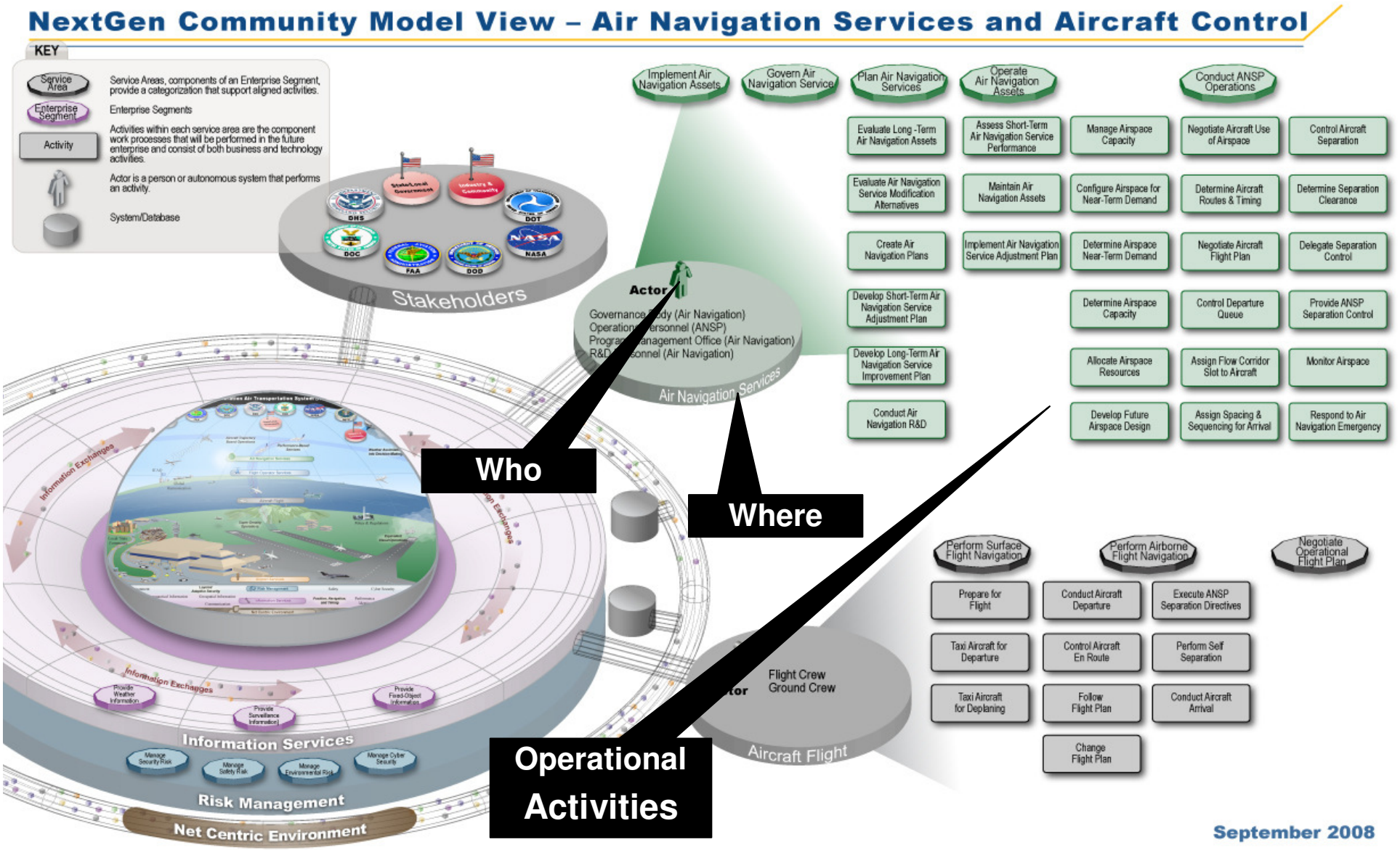
NextGen 2025 Enterprise Architecture



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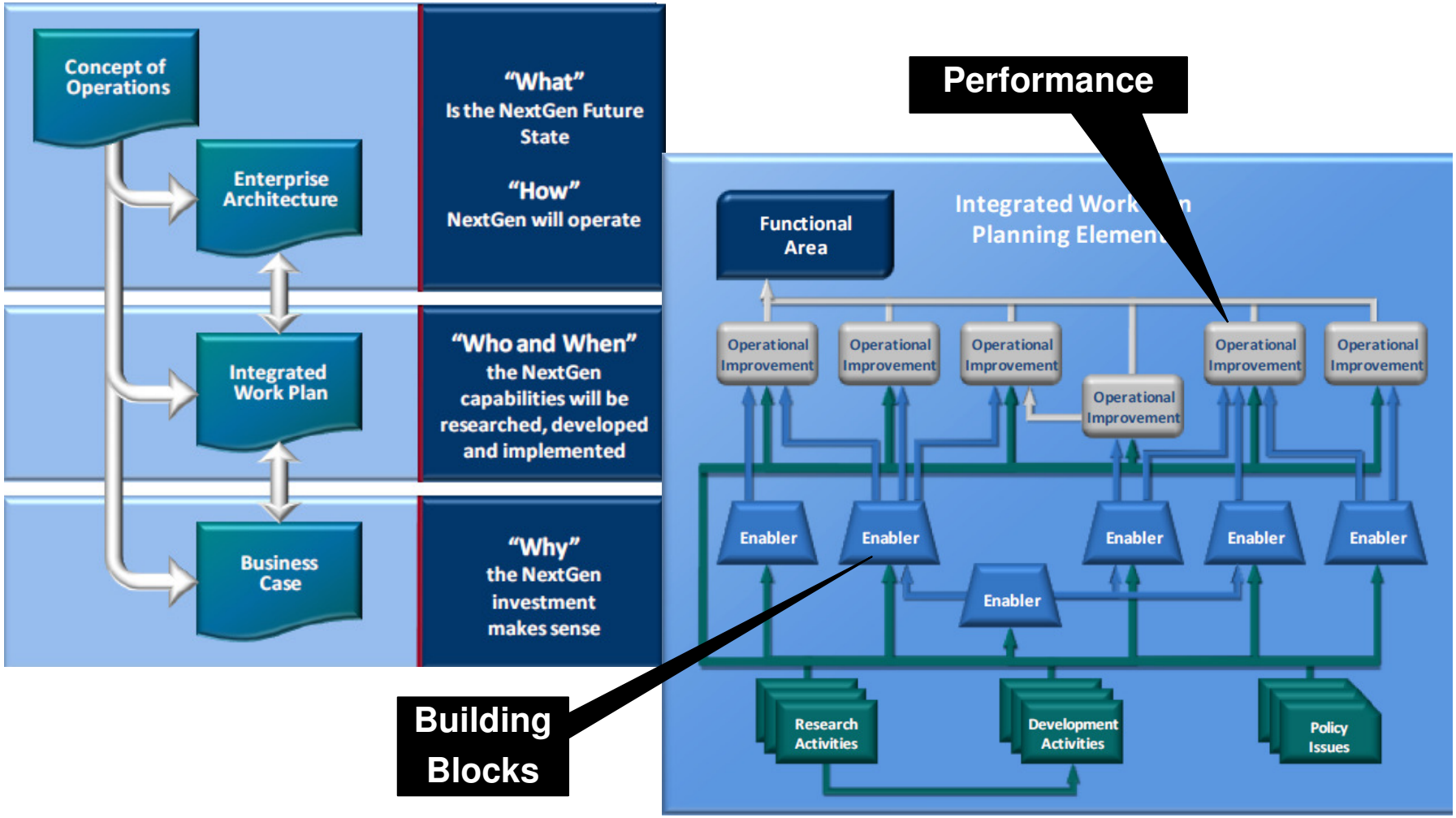
JPDO Integrated Work Plan



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Key tool for the process - JPE

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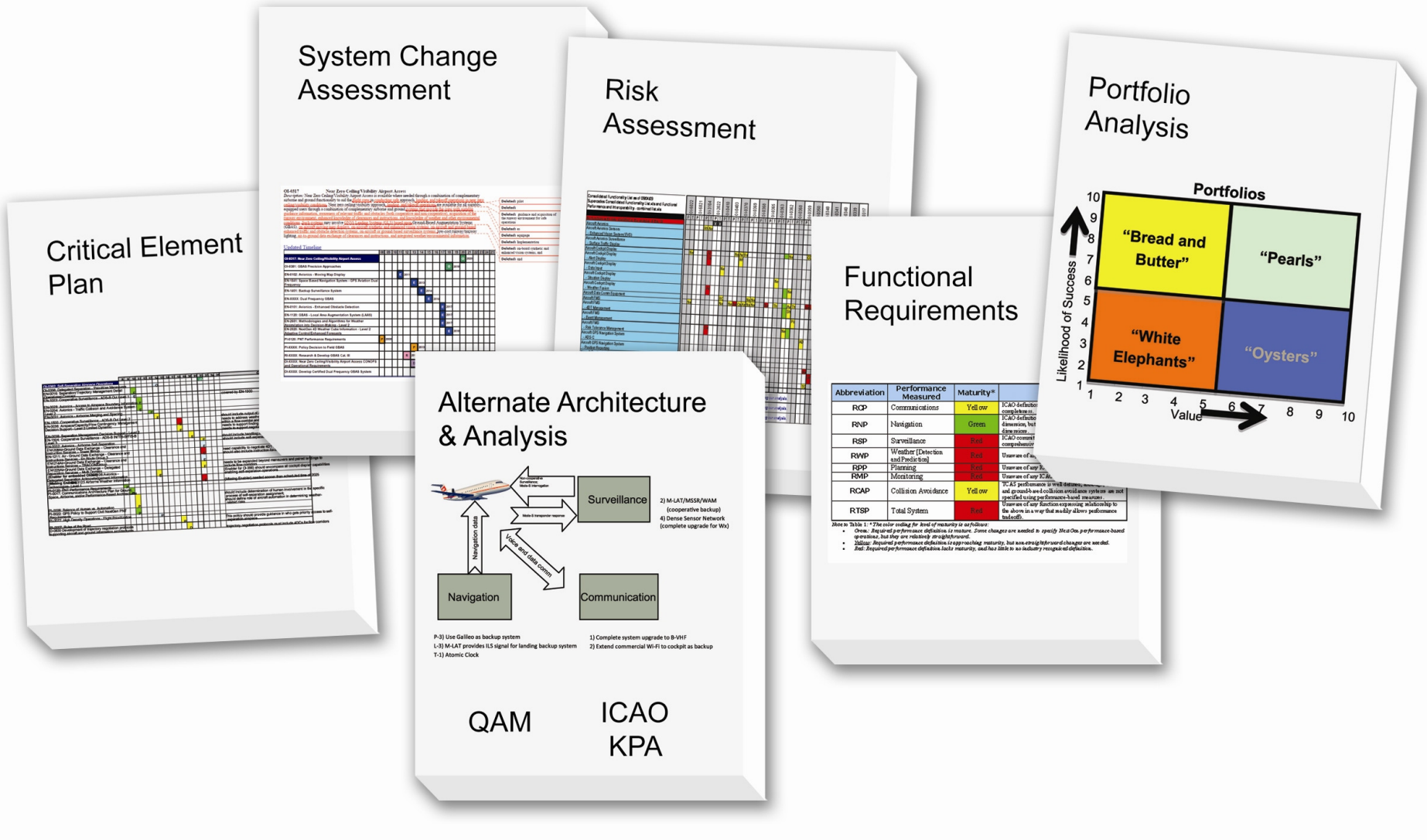
Results



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Critical Element Action Plan

OI Title OI-0362 Self-Separation Airspace Operations
Critical Activity Title Tools for self-separation in flow corridors

Actions

1. Policy to determine human involvement in the process of selection of flights for self-separation assignment
2. Policy to determine who gets priority to flow corridors
3. Support for finding entry slot for flow corridor and for performing exit negotiation for flow corridor
4. Development of trajectory negotiation protocols that include 4DT Constraints (4DCs) for flow corridors
5. Capability to negotiate 4DCs rather than precise 4DTs
6. Tools to enable delegation of self-separation in flow corridors

Goals

By 2022, provide ANS with tools to help assign slots and negotiate 4DCs in self-separation flow corridors and to delegate separation authority to flight deck;

Also provide aircraft with 4DC negotiation capability;

Time Line

Action	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	P													
2							P							
3							E							
4								D						
5											E			
6											E			

Recommended Approach

Provide ANS with toolset to select self-separation aircraft for flow corridors and to assign flow corridor slots.

Develop and implement flow corridor 4DC negotiation protocol at ANS and aircraft.

Implement tools for delegation of self-separation and negotiation of end of self-separation.

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System Practice Change Assessment

OI-0317 **Near Zero Ceiling/Visibility Airport Access**

Description: Near Zero Ceiling/Visibility Airport Access is available where needed through a combination of complementary airborne and ground functionality to aid the flight crew in conducting safe approach, landing, and takeoff operations in near zero ceiling/visibility conditions. Near zero ceiling/visibility approach, landing, and takeoff operations are available for all suitably-equipped users through a combination of complementary airborne and ground systems that provide the crew with suitable guidance information, awareness of relevant traffic and obstacles (both cooperative and non-cooperative), acquisition of the runway environment, enhanced knowledge of clearances and instructions, and knowledge of weather and other environmental conditions. Such systems may involve GNSS Landing Systems (GLS) based upon Ground-Based Augmentation Systems (GBAS), on-aircraft moving map displays, on-aircraft synthetic and enhanced vision systems, on-aircraft and ground-based enhanced traffic and obstacle detection systems, on-aircraft or ground-based surveillance systems, low-cost runway/taxiway lighting, air-to-ground data exchange of clearances and instructions, and integrated weather/environmental information.

Deleted: pilot

Deleted:

Deleted: guidance and acquisition of the runway environment for safe operations

Deleted: es

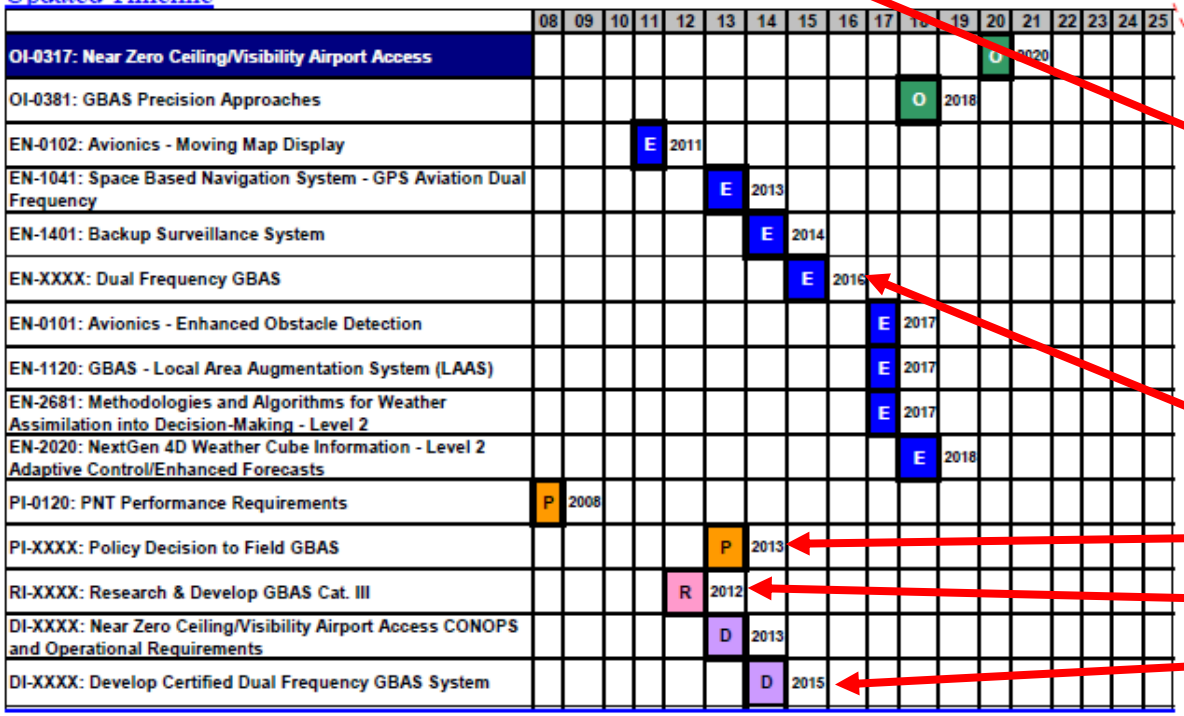
Deleted: equipage

Deleted: Implementation

Deleted: on-board synthetic and enhanced vision systems, and

Deleted: and

Updated Timeline



Revised Description

Updated Timeline showing new elements:

- Enablers
- Policies
- Research
- Development,

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Functional Requirements

Note: This assessment based on the Scenarios utilized

Abbreviation	Performance Measured	Maturity*	Gaps
RCP	Communications	Yellow	ICAO definition exits Minor gaps in coverage & completeness
RNP	Navigation	Green	ICAO definition is mature in the horizontal dimension, but requires extensions to vertical & time dimensions.
RSP	Surveillance	Red	ICAO committee exists but has not completed a comprehensive specification.
RWP	Weather [Detection and Prediction	Red	Unaware of any ICAO or FAA definition
RPP	Planning	Red	Unaware of any ICAO or FAA definition
RMP	Monitoring	Red	Unaware of any ICAO or FAA definition
RCAP	Collision Avoidance	Yellow	TCAS performance is well defined, although, TCAS and ground based collision avoidance systems are not specified using performance based measures
RTSP	Total System	Red	Unaware of any function expressing a relationship to the above in a way that readily allows performance tradeoffs.

Note to Table 1 *: * The color coding for level of maturity is as follows :*

- *Green : Required performance definition is mature . Some changes are needed to specify NextGen performance - based operations, but they are relatively straightforward.*
- *Yellow: Required performance definition is approaching maturity, but non - straightforward changes are needed.*
- *Red : Required performance definition lacks maturity, and has little to no industry recognized definition.*

Alternate Architecture Analysis – Quality Attributes Matrix (QAM)

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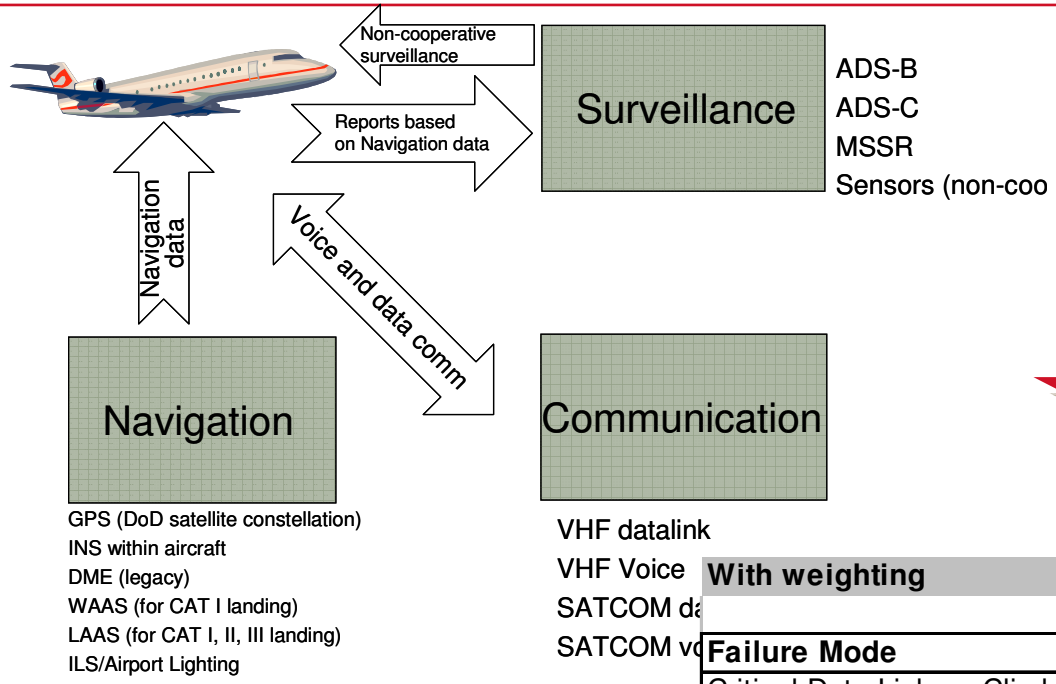

NextGen Baseline and Alternate architecture defined and evaluated

QAM Assessment Scores based on 1 – 5, where 5 is best case

With weighting			
	QAM Score		
Failure Mode	**Baseline**	**Alternate**	**Ratio**
Critical Data Link on Climb	2.85	4.54	1.59
GNSS Failure on Landing	2.84	3.72	1.31
ADS-B Failure in Super Density Terminal	2.21	3.84	1.74
Wx Sensor Failure in Super Density Terminal	2.84	4.4	1.55

Without weighting			
	QAM Score		
Failure Mode	**Baseline**	**Alternate**	**Ratio**
Critical Data Link on Climb	2.83	4.50	1.59
GNSS Failure on Landing	3.00	3.75	1.25
ADS-B Failure in Super Density Terminal	2.25	3.25	1.44
Wx Sensor Failure in Super Density Terminal	2.92	4.42	1.51

Alternate Architecture Analysis – ICAO KPAs

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	Baseline		Alternative I		Alternative II	
Communications	VDLM2, VHF Voice, SATCOM Voice, SATCOM	0.35	VHF Broadband	-0.18	Commercial Wireless	0.00
Navigation	GPS, INS, DME, WAAS, LAAS	0.82	Alternate GNSS, dual GNSS receiver	0.73	M-LAT to provide ILS signal	0.00
Surveillance	ADS-B, ADS-C, Sensors	0.00	Legacy M-LAT/MSSR with WAM	0.27	Legacy M-LAT/MSSR with WAM	0.27
Summary		1.18		0.82		0.27

- Baseline Architecture Assessment Was Most Positive
- Alternate Architectures For Some Functional Capabilities Were Equal or Better
- Tightly Integrated CNS architectures may offer a higher score (simply the sum of the parts) – potential subject of follow-on work

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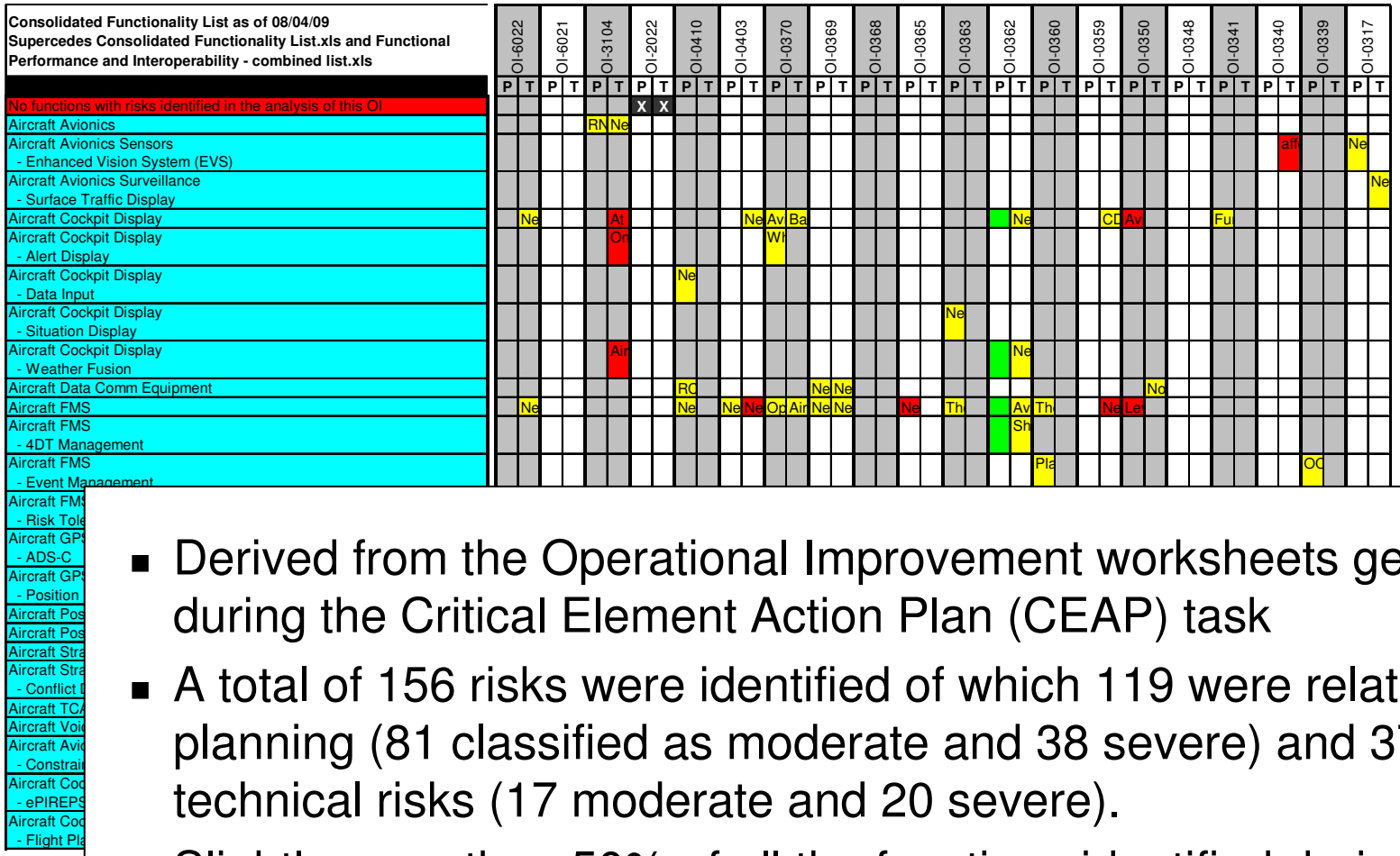
Risk Assessment

Consolidated Functionality List as of 08/04/09
Supercedes Consolidated Functionality List.xls and Functional Performance and Interoperability - combined list.xls



- Derived from the Operational Improvement worksheets generated during the Critical Element Action Plan (CEAP) task
- A total of 156 risks were identified of which 119 were related to planning (81 classified as moderate and 38 severe) and 37 were technical risks (17 moderate and 20 severe).
- Slightly more than 50% of all the functions identified during the iCNS program have risks associated with them.
- Only one OI (2022) does not have any risks associated with it

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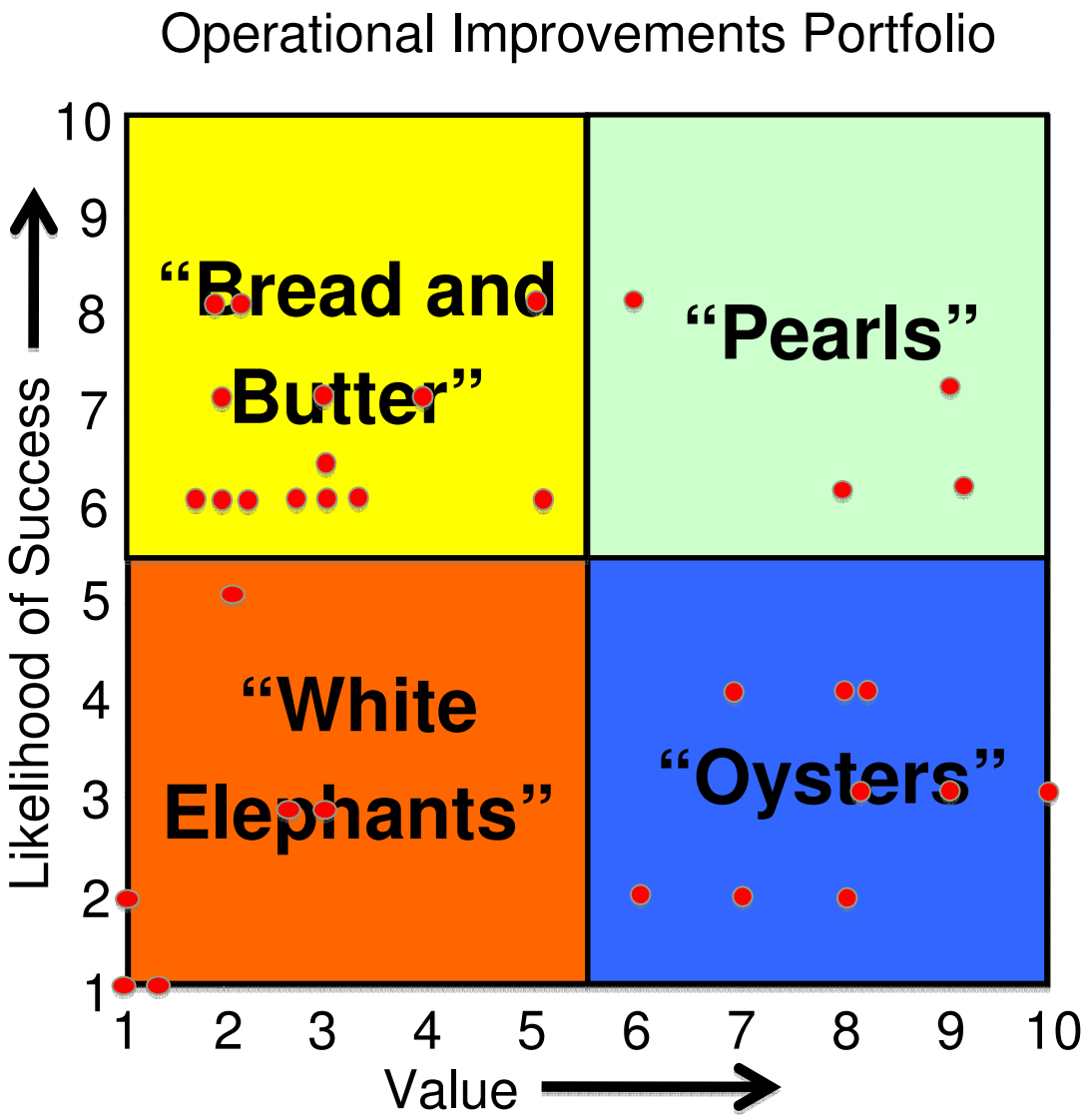
Portfolio Analysis



White Elephants – unlikely to enjoy technical success or produce substantial value.

Bread & Butter – High chance of success and adequate value, incremental builds on existing technology base.

Oysters – Early stage projects designed to produce strategic advantage and market transformations, high value and high risk. Oysters make pearls.

Pearls – revolutionary, transforming, risks well managed and value can be realized.

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Certification

- Re-evaluate RTCA Task Force 4/5 recommendations
- Expand SAE 4761 concept to system-of-systems.
  - Establish target levels of safety for the NextGen operations level
  - Allocate the target levels of safety to each of the NextGen nodes.
  - Establish the basis of certification for NextGen operations.
  - Streamline the Operational Approval processes since many NextGen operations involve interactions between multiple aircraft and ground systems.
- Extend the DO-264 methodology, for both aircraft and ground systems, to include:
  - identification of safety objectives,
  - allocation of safety requirements, and
  - determination of nominal performance of all system components that support the performance-based NextGen operational concepts.
- Evaluate on-going certification and approval processes in use within the European Union for applicability to NextGen.
- Accelerate industry work to develop the RTSP concepts

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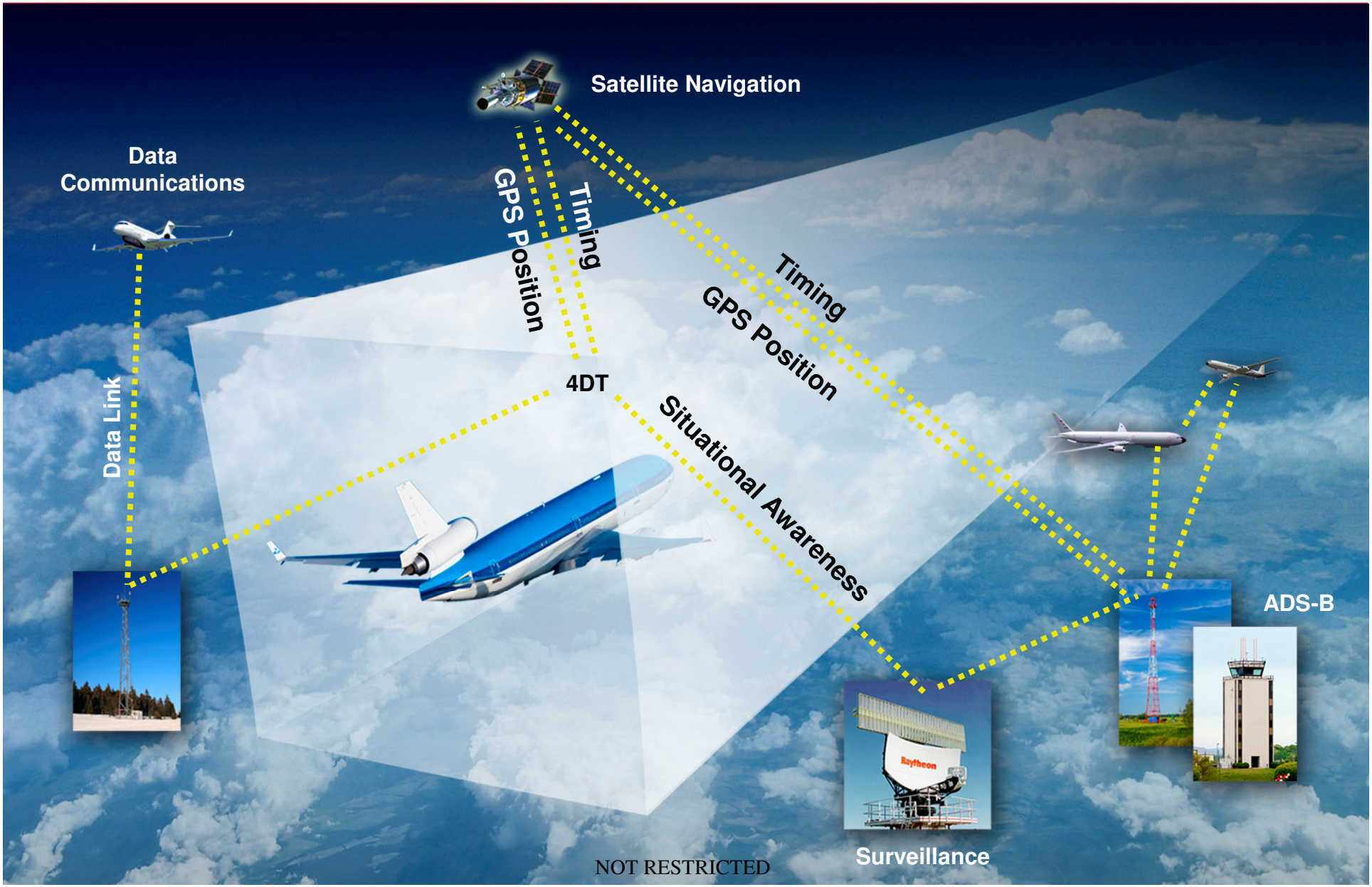
NextGen ICNS Architecture Dependency



NOT RESTRICTED

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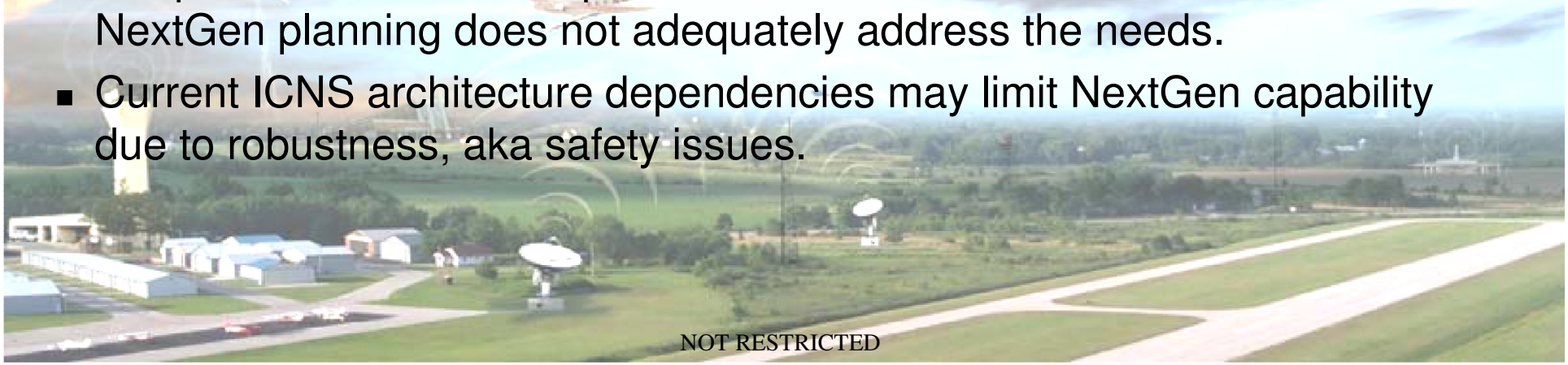
Key Findings

- Most of the “building blocks” of the NextGen Plan do not address specific requirements for Comm, Nav, and Surveillance.
- Although the capabilities analyzed are planned for 2018-2025, they are built on research, policy updates, and functionality being developed from **now** through 2025.
- Capability in the aircraft cockpit and flight operations must be enhanced to take advantage of NextGen ICNS.
- Data Communication “building blocks” are not well defined.
- Back-up Navigation capability must be established within the planning now.
- Cooperative and non-cooperative surveillance is essential, current NextGen planning does not adequately address the needs.
- Current ICNS architecture dependencies may limit NextGen capability due to robustness, aka safety issues.



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Recommendations

- The JPDO should update the Integrated Work Plan and make available via the Joint Planning Environment website.
  - Strengthen the capability, research, and policy initiatives to address the shortcomings identified
- A complete “Robustness” analysis of current and alternate ICNS Architectures should be conducted now.
  - Address the potential safety issues arising from equipment failures
- The Scenario based analysis should be applied to the FAA’s Enterprise Architecture and supporting plans as it becomes available.
- The FAA should implement a public access website similar to the JPE to facilitate stakeholder understanding and evaluations.

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Summary

- The ICNS Study has generated significant insights into NextGen implementation
- The Raytheon team ‘s success demonstrates the value of the JPDO’s Enterprise Architecture, Integrated Work Plan and the Joint Planning Environment
- The FAA’s NextGen Implementation Plan and the associated Enterprise Architecture efforts will benefit from the lessons learned on the ICNS Study.